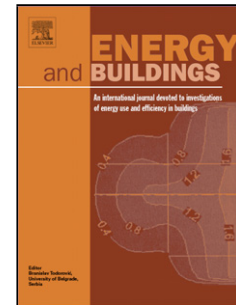


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Energy retrofit interventions in historic buildings: exploring guidance and attitudes of conservation professionals to slim double glazing in the UK

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Abstract

In the UK, 20% of houses were built before 1919 and are protected from energy efficiency requirements that would unacceptably alter their character. To meet carbon emission reduction targets, however, it is necessary to keep the number of buildings exempt from energy efficiency improvements to a minimum. The need to preserve the aesthetic and structural qualities of historic buildings makes energy retrofit complicated and costly but these arguments should not be used to resist change. The research presented in this paper investigates how conservation professionals in the UK approach and sanction energy retrofit measures in historic buildings. It provides an overview of the current UK legislation and guidance relating to energy efficiency in heritage buildings and presents findings from a study focused on the approach of conservation professionals to retrofit slim profile double glazing (SPDG). It finds that there is regional variation to energy retrofit in historic buildings between Scotland and the rest of the UK, and that individual conservation professionals hold different views on the use of SPDG, which leads to inconsistencies in its application. Recommendations are made for a more consistent approach to window upgrade as a means of improving the energy efficiency and comfort of historic buildings and for greater interdisciplinary cooperation to align conservation of energy with conservation of heritage.

Keywords: Energy efficiency; historic buildings; conservation; windows; slim profile double glazing; retrofit.

1. Introduction

Improving the energy efficiency of historic buildings is vitally important, not only as a means of protecting them from emptiness and dereliction, but also as an essential element of any emission reduction strategy in the built environment. Research in 2005 showed that the UK

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residential housing sector could deliver a 60% reduction in CO₂ emissions by 2050 if the average heat loss of all existing housing was cut by one third [1]. A large proportion of the UK housing stock (20%) are historic buildings built before 1919 [2], which often have particularly high energy consumption. A study of pre-1919 houses in Bath, showed that their average energy consumption was 195 kWh/m² per annum [3]. A report by the BRE in 2005 found that the average energy consumption of pre-1919 houses in England was 25,475 kWh/per household/per year compared to 18,634 kWh/per household/per year for houses built post 1980 [5]. EU directives dictate energy efficiency standards on buildings undergoing renovation or extension but these do not extend to historic buildings [6]. As a result, countries set their own rules. In the UK, the regulations are such that historic buildings are often exempt from energy efficiency requirements. However, to meet the CO₂ reduction targets, the number of buildings exempt from energy efficiency improvements has to be kept to a minimum. Exempting historic buildings from energy efficiency improvements not only relegates people to live and work in polluting, uncomfortable dwellings that are expensive to run but also forces unrealistic CO₂ reductions on other properties. This is particularly significant in cities such as London and Bath, where the concentration of historic buildings is higher than the UK average [3][4].

A growing body of academic research seeks to align energy conservation with heritage conservation in EU countries, including the evaluation of energy efficiency in historic buildings in Italy [7]; and a study on the need for interdisciplinary cooperation to overcome barriers to renewable energy in heritage buildings in Switzerland [8]. In the UK, there are a number of government-funded heritage agencies who publish guidance documents on how best to improve the energy efficiency of historic buildings. Little research has been done into comparing the guidance for different parts of the UK or investigating how it is interpreted in practice. This paper seeks to address this gap in knowledge and investigate how guidance is implemented in relation to window retrofit.

In the UK, windows have become a focal point for energy efficiency improvements in historic buildings for a number of reasons. Double glazing not only reduces heat loss but also condensation and noise, and therefore has a positive impact on occupant comfort levels. When traditional windows fail, property owners look for opportunities to improve both energy efficiency and comfort. The development of slim profile double glazing (SPDG) makes

it possible to improve the U-value of windows without ‘unacceptably’ altering the appearance of a building. SPDG is thin enough (ranging from between 8.2 and 16mm in depth) to be fitted into some existing single glazed window rebates or can be used in new windows that replicate a traditional profile. Depending on the type of SPDG used, the U-value (centre of pane) can range between 1 W/m² K to 2.8 W/m² K which, depending on the style of window, can result in heat loss reductions of between 63% and 73% compared to single glazing [9]. Table 1 illustrates the differences between a window fitted with single glazing and the different replacement options. As illustrated in the table, normal double glazing has an edge seal, the material that separates the two panes of glass, which is about 10mm deep. SPDG has varying depths of edge seal depending on the manufacturer but typically they tend to range from between 5-7mm. The slim line unit is designed with narrower edge seals so that it can be fitted into finer frames/glazing bars. In order to cover up the edge seal, the rebate that the glass sits in needs to be at least 2mm deeper than the edge seal, i.e. between 7-9 mm in the case of SPDG and at least 12 mm in the case of normal double glazing. Please note, there are many variations in edge seal/frame rebate depending on manufacturer, so the sketches and dimensions given in Table 1 are not to scale and are included here for illustrative purposes only. Typical depths and U-values given in the table are based on current guidance.

Despite the energy efficiency benefits of SPDG, there are some concerns regarding the use of this type of glazing in historic buildings, such as accelerated loss of historic glass; need for thicker glazing bars to support the increased weight; and a flatter, more uniform reflection compared to old glass.

The research presented here specifically focuses on listed buildings - buildings that are protected because of their historic/architectural value. In the UK, any alteration or extension to a listed building requires consent from the local authority where it resides. Most local authorities employ conservation professionals to decide on the appropriateness of alterations. They play a key role in determining whether energy efficiency improvements can be made to the building envelope. Local authorities are required by law to publish online all their decisions relating to alterations to listed buildings.

This paper presents results from a study investigating the approach of UK conservation professionals to SPDG in listed buildings. Primary and secondary data sources are utilized to explore current legislation and guidance in different parts of the UK and to investigate how

authorisation for improvements varies between the regions, using window retrofit as an example. Recommendations are made for improving guidance and procedures.

2. Methodology

The study comprised two main elements. Firstly, a review was undertaken of the legislative framework and guidance literature on energy efficiency in historic buildings. Differences between the guidance for England, Scotland and Wales were explored.

Secondly, a multi-method data collection was conducted to gather information on the approach of UK conservation professionals to the use of slim profile double glazing. This comprised 1) a questionnaire survey to gather quantitative and qualitative data regarding conservation professionals' approaches and opinions; 2) interviews to further explore specific issues and 3) online analysis of local authority decisions to install SPDG in listed buildings. The intention was to derive an understanding of the current processes and use of legislation and guidance across the UK, and particularly to find out how conservation professionals opine on changes to historic buildings and what shapes their decisions.

2.1. Survey

A web-based survey form was developed that consisted of 35 questions, designed to reveal the opinions and approach of conservation professionals to energy efficiency and SPDG and to show how legislation and guidance is interpreted in practice. The survey included questions on whether conservation professionals agree or disagree that energy efficiency in listed buildings is important; the circumstances under which they allow slim profile double glazing to be used; and their greatest concerns associated with it. A few questions were not opinion-based and required simple answers such as indicating which guidance documents they refer to. Most questions were closed-ended with 'further comment' fields for those wanting to qualify their responses. For questions revealing behaviour, three point Likert frequency scales (never, occasionally, frequently) were used, whilst for those revealing opinion, Likert four point agree/disagree scales were used.

The survey was initially intended to gather mainly quantitative data. However, the respondents made extensive use of the 'further comment' field and thus provided a wealth of qualitative data.

A link to the web-based survey was emailed to 200 conservation professionals across the UK in April 2014. There were 52 completed surveys returned, giving a response rate of 26% (see section 3.2 for further details).

2.2. Interviews

It was intended that interviews would be carried out for qualitative data collection purposes, i.e. to help interpret the quantitative data from the survey. The need, however, for interviews was reduced by the extensive use of the 'further comment' field by respondents. The interviews were carried out over the telephone and were of a semi-structured nature following up on themes that emerged from the survey, such as the decision procedure on window applications in historic building; discussion over the reasons for opposing or supporting SPDG in historic buildings; and examples of SPDG being installed in notable buildings.

Interviewees were recruited through the questionnaire survey: at the end of the survey respondents were asked if they would be prepared to be interviewed. Overall, seventeen people responded 'yes' but only seven of those actually took part in interviews, of which four were from England, two from Scotland and one from Wales.

2.3. Local planning authority databases

All UK local authorities maintain online databases of applications to alter listed buildings [11]. These are publically available and can typically be accessed through the planning section of local authority websites. Filters can be applied in the database search feature in order to refine the selection of archived planning applications, e.g. to only display those relating to windows in historic buildings. Supporting documentation and decision notices can then be accessed. The data is potentially extremely useful because it provides evidence of how property owners are applying to improve the energy efficiency and comfort of their historic buildings and how conservation professionals are responding to these applications. However, due to the design of the database interface, the extraction and profiling of data is an onerous, manual process. This restricted the use of this resource in the study.

Seven local authority databases were selected for analysis and case studies of similar applications to replace windows with SPDG were identified. For each case, a variety of documents were viewed (e.g. listed building consent applications; design and access

statements; heritage statements; and elevation diagrams of proposed window alterations) and the resultant decisions, either to grant or refuse consent, were compared. The data was also used to explore differences in the techniques used to incorporate SPDG in traditional windows.

3. Results

The results from the study are presented here in two parts. The first part reviews current legislation and procedures for retrofitting historic buildings in the UK and brings together findings from the literature study and feedback from the conservation professionals who use this guidance on a day-to-day basis. The second part explores differences in practice, approach and attitude between the UK regions and within one region (England), focusing on window retrofit as an example.

3.1 Review of current UK legislation and guidance on energy efficiency in historic buildings

This section is mostly based on a review of legislation, guidance documents and relevant academic literature but, where appropriate, also makes use of relevant qualitative data gathered through the survey and interviews.

3.1.1 *Legislation*

The Energy Performance Building Directive (EPBD) requires EU member states to reduce the energy consumption of existing buildings when they are undergoing major renovation or retrofitting of technical elements. A derogation regime exists whereby member states are able to exempt historic buildings from the requirements of the EPBD if compliance would unacceptably alter their character or appearance.

In the UK the EPBD is implemented through the Building Regulations and their accompanying guidance documents – Approved Documents (in the case of England and Wales) and Technical Handbooks (in the case of Scotland). In England, Part L of the Building Regulations deals with the conservation of fuel and power in both new dwellings (L1A) and existing dwellings undergoing renovation (L1B). These regulations also apply to Wales, although some adaptations were introduced in 2014. However, in regards to the points relevant to this paper, the Part L legislation is identical in England and Wales. Scotland has its own regulations called the Building Standards (Scotland) Regulations, and Section 6 of the Domestic Technical Handbook deals with energy in both new and existing dwellings undergoing renovation. As

specified in the EPBD, certain buildings can be exempted from these energy efficiency rules. In the UK this is regulated as follows.

In England and Wales, listed buildings and those within conservation areas are exempt from compliance if the changes would unacceptably alter the character or appearance of the building [12]. There are also special considerations for non-exempt buildings of traditional construction where they only have to improve their energy efficiency where ‘reasonably practical’.

In Scotland, listed and traditionally constructed buildings are not offered the same level of exemption as in England and Wales. The Building Regulations offer flexibility as to how minimum standards are achieved with an emphasis on improvements being ‘as close to the full requirements as reasonably practicable’ [13]. In areas where compliance is not possible, there is a requirement for compensatory improvements elsewhere.

Unlike in new buildings, the absence of a European protocol for the energy retrofit of historic buildings has restricted the development of benchmarks to measure their energy use and precluded the emergence of appropriate methodologies and guidelines on how best to achieve energy conservation. The fact that England and Scotland have interpreted the EPBD differently in relation to their historic buildings shows that the lack of uniformity, identified by Mazzarella between EU countries [6], also exists within the UK.

With over 400,000 listed buildings and approximately 1.2m dwellings in conservation areas, it is estimated that about 5% of the total UK housing stock potentially falls outside the remit of Part L (England and Wales) and Section 6 (in Scotland) of the Building Regulations [1]. The caveats for listed buildings, conservation areas and traditionally constructed buildings are not designed to provide blanket exemption but, in reality, the difficulty of deciding at what point an alteration becomes ‘unacceptable’ or not ‘reasonably practical’ means that energy efficiency improvements in historic buildings are hard to enforce if there is no inclination from the owners to make them. Furthermore, in some local authority planning departments, building control bodies (approved inspectors, who either work for private companies or are employed by the local authority, and ensure that building regulations are complied with) defer to conservation professionals in relation to exempted buildings and thus have limited influence over the resultant energy efficiency of renovation works. For example, of the seven

conservation professionals interviewed, five said that they rarely or never experience building control intervention with listed buildings. They expressed the view that building control consider any improvements in energy efficiency levels to exempted buildings to be sufficient to meeting energy conservation requirements.

In the UK, the two main pieces of legislation affecting alterations and improvements to historic buildings are the Planning Act² 1990 and the National Planning Policy Framework (NPPF). Conservation professionals are required to consider applications to change a historic building in light of the impact on its character and building envelope, as specified by the Planning Act. However, the NPPF, which greatly simplifies the complex planning system, emphasises sustainable development and the need to enhance the significance of heritage assets and put them to viable uses consistent with their conservation [12].

As outlined above, conservation professionals play a key role (often with more decision-making power than building control bodies) in determining whether energy efficiency improvements impacting the envelope of historic buildings can be made. However, it is not clear how significantly the NPPF influences the approach of conservation professionals. Comments gathered through the survey seem to indicate that some conservation professionals primarily focus on the impact of alterations on historic character and building envelope whilst others make efforts to align conservation with the principles of sustainable development as set out in the NPPF. For example, one respondent (from England) commented that he strongly disagreed with historic buildings being energy efficient and that ‘people’s efforts to upgrade them are a huge problem’. Another respondent (from Scotland), however, made it clear that they preserve historic material where possible but will sanction its removal if the long term viability of a building is at risk.

In summary, the flexibility granted on how the EPBD is interpreted in relation to historic buildings appears to have restricted the development of commonly agreed guidelines and procedures on how and what energy efficiency improvements should be encouraged. The following section further explores to what extent this lack of uniformity in approach exists between different heritage organisations in the UK.

² In England and Wales historic buildings are protected by the Planning (Listed Buildings & Conservation Areas) Act 1990 and in Scotland by the Planning (Listed Buildings & Conservation Areas) (Scotland) Act 1997.

3.1.2 *Heritage Agency Guidance*

The Heritage Agencies, i.e. Historic England, Historic Scotland and Cadw (for Wales), are the agencies of government responsible for protecting historic buildings. One of their responsibilities is to facilitate research and issue guidelines on how best to preserve and improve heritage buildings to secure their existence.

Results from the survey show that conservation professionals across the UK rely significantly on Heritage Agency guidance to inform their decisions. Of those surveyed, 62% indicated that they ‘frequently’ rely on it, whilst 37% indicated they ‘occasionally’ rely on it. However, the literature shows that there are distinct differences in the focus and approach taken by the different agencies.

Historic England encourages energy efficiency improvements in historic dwellings as long as they do not damage the character or long-term health of the building [14]. The guidance is more supportive of non-invasive interventions compared to measures that impact the building envelope. Up until 2014, Historic England were extremely reticent about the use of slim profile double glazing (SPDG) in historic buildings. In their latest guidance, however, they have softened their approach and recognise that in some contexts SPDG may be suitable [15].

Historic Scotland have been more proactive in embracing energy efficiency in heritage buildings. Their joint publication with the Scottish Buildings Standards Agency (SBSA) approaches the retrofit of historic buildings from the perspective of improving their comfort levels and reducing their carbon footprint [13]. They have supported the use of SPDG as a means of improving the thermal performance and comfort levels of traditional dwellings and have commissioned a number of pieces of research on it [9][18]. For example, a conversation with a technical researcher at Historic Scotland revealed that they have engaged with the manufacturers of SPDG to shape the end product to their conservation specifications.

Cadw, the Welsh heritage agency, tends not to issue its own guidance papers on energy efficiency in heritage buildings and, as a result, Welsh conservation professionals are expected to rely on guidance from Historic England and Historic Scotland. However, although 100% of the Welsh conservation professionals who took part in the survey are aware of the Historic England guidance and 63% are aware of the Historic Scotland guidance, only 25% of

them said that they refer to it frequently, compared to 74% of conservation professionals from England and 44% from Scotland.

The extent to which the differences in guidance between the different parts of the UK are reflected in the attitude and approach of individual conservation professionals is explored in the following section.

3.2. Approach of conservation professionals – how legislation and guidance is implemented

This section brings together quantitative and qualitative data from the survey responses and interviews, further supported by information from the local authority planning databases.

The most survey responses (35) were received from conservation professionals working for local authorities in England, whilst nine were received from Scotland and eight from Wales. Respondents were asked to indicate how long they had worked as conservation professionals. The largest number of respondents (21) had worked as conservation professionals for between 11-20 years; 17 had worked for between 1-10 years; eight had worked for longer than 20 years; two had worked for less than a year; and four did not answer.

3.2.1 *General attitudes towards energy efficiency*

Of the 52 conservation professionals who responded to the survey, 90% agreed or strongly agreed that energy efficiency in listed buildings is important. All of the respondents who disagreed were working for local authorities in England (Figure 1).

To test further how receptive conservation professionals are towards making historic buildings more energy efficient, they were asked how often they stipulate that single glazing be used where a traditional window needs to be replaced. The majority of respondents (54%) indicated 'frequently', 35% indicated 'occasionally' and 12% answered 'don't know'. Regional analysis showed that 71% of conservation professionals from England (25 out of 35) said they would frequently stipulate single glazing as opposed to 11% from Scotland (one out of nine) and 25% from Wales (two out of eight) (Figure 2). Despite the small sample sizes, this data indicates that in England, conservation teams are extremely focused on maintaining historic integrity and are less prepared to compromise it for energy efficiency measures than conservation professionals working in Scotland and, to a lesser extent, Wales.

3.2.2 *Trends and concerns regarding the utilisation of SPDG in listed buildings*

According to survey data, applications to install SPDG in listed buildings have been increasing. When conservation professionals were asked whether they had seen an increase in the past five years, 67% of them said they had experienced a small increase and 21% indicated a significant increase.

The use of SPDG, however, clearly depends on the predilection of conservation professionals to sanction it. As noted above, there are a range of concerns regarding the suitability of SPDG for historic retrofit. In order to explore which aspects conservation professionals regard as most problematic, questionnaire respondents were asked to rank different concerns. This included the thickness of glazing bars required to support the SPDG; reflection characteristics; the visibility of edge seals surrounding the SPDG units; the appearance of the spacer bars (the material separating the two glass panes in a double glazed unit); concerns over lifespan; and issues relating to the bedding materials used to hold the panes in place. As shown in Table 2, the greatest concern, by a considerable margin, was the thickness of glazing bars (as indicated by the low mean ranking value of 1.89 and lowest rank value of 5). Most respondents ranked this as either their first or second choice and a low standard deviation shows that there was consensus on this issue. A flat, uniform glass reflection as opposed to the dappled, irregular reflection from single glazing was ranked as the second greatest concern (mean ranking value of 3.09), followed by the colour/look of the spacer bars. However, a higher standard deviation indicates that there was a wider spread within the response data and for some people these were of no concern at all, as indicated by '8' being the lowest ranking value .

A large variability in opinion can be observed for the other concerns (all spread between ranking values of 1 and 8 with a mean in the middle of the available range, from 4.26 to 4.81). In the instances where 'other' was attributed a high ranking, comments showed that the concerns were either related to loss of historic material, including glass and carpentry detail, or because of the belief that the cost of SPDG outweighs the energy efficiency benefits. In terms of lifespan, most respondents indicated that other issues were of a greater concern to them. However, a number of them indicated, in the further comment field, that they were aware of some units failing (leading to condensation build up) and that this concerned them.

3.2.3 *Differences in approaches and attitudes to using SPDG across the UK*

Figure 3 shows the disagreement amongst conservation professionals when asked whether they consider SPDG to be an important factor in improving the thermal performance of listed buildings. Of all respondents, 46% agreed with the statement whilst 39% disagreed. Further analysis indicated that in England 45% of respondents (16 out of 35) disagreed with Question 2, compared to only 22% in Scotland (two out of nine) and 25% in Wales (two out of eight). All the responses indicating strong disagreement came from conservation professionals operating in England. This suggests that SPDG is looked on more favourably as an energy efficiency tool in historic buildings in Scotland and Wales than in England.

Table 3 presents data relating to applications to renovate or replace windows in historic buildings in the Scottish city of Edinburgh and the English area of Bath and North East Somerset (BANES) in the six months from 1 October 2014 to 1 April 2015. It shows that in Edinburgh there were a total of 64 applications for window improvements compared to 21 in BANES. In Edinburgh, 89% (57) of these applications requested for SPDG to be used whilst only 11% (7) requested single glazing. In BANES, 43% (9) of the applications were for SPDG compared to 57% (12) for single glazing. Furthermore, Table 3 shows that only 2 out of the 57 applications for SPDG in Edinburgh were refused consent whilst in BANES the proportion was higher, with 2 out of 9 applications for SPDG refused consent.

Survey responses provide further insight; 33% of surveyed conservation officers in Scotland indicated a 'significant increase' in SPDG applications compared to 20% in England and 13% in Wales. Also, a conservation officer from Edinburgh City Council indicated in the interview that they had experienced a 'significant increase' in the number of applications to replace windows in listed properties with SPDG over the past 5 years. This data suggests that where a local authority, like Edinburgh, actively embraces SPDG in historic buildings, strong demand can ensue from property owners to make traditional windows more energy efficient. This is explored further in the discussion section.

The survey data further indicated that one area of stark variation between English/Welsh and Scottish conservation professionals was in their approach towards the retrofitting of slim double glazed panes within existing window frames, i.e. a compromise whereby original

joinery is retained whilst improving energy efficiency. An overwhelming majority of Scottish respondents (78%) said they would be more likely to approve the fitting of SPDG panes into an existing window frame than approve an entirely new SPDG window. This compares to only 37% of English respondents and 25% of Welsh respondents.

The comments accompanying this survey question provide further insight into the underlying attitudes. For example, one Scottish conservation officer commented that retrofitting is “the method of replacement that we try to encourage,” whilst another said they “had seen many examples of where it had worked well.” In contrast, English and Welsh conservation professionals commented that “the rebate required is usually too damaging;” “it is difficult to achieve in practice due to the heavier weight of the glass;” and that it is “very hard to find joinery firms who are skilled at carrying out this type of work.” These comments suggest that in Scotland conservation professionals have positive experiences of this procedure being carried out successfully, which is not the case in England or Wales.

3.2.4 Consistency of decisions regarding SPDG in England

As noted above, there seems to be a contrast in approach and attitude to SPDG in the different regions of the UK. In order to investigate further how consistent regional approaches are, the results in this section refer specifically to conservation professionals working in local authorities in England.

Although planning authorities in England are subject to the same legislation and heritage guidance (Part L, the Planning Act 1990, the NPPF and Historic England publications) qualitative data collected through the interviews and questionnaire comments indicate that there are noticeable inconsistencies in approach between them. In some cases this results in SPDG applications that may have been granted consent in one local authority being refused in another.

The following quotes from English conservation professionals demonstrate a wide spectrum of attitudes towards SPDG from within the same UK region:

- SPDG units, “by definition will always be an intrusive and inappropriate modern alteration.”
- “We consider SPDG unacceptable, in principle, in 18th and 19th century buildings but we do allow it in some 20th century commercial buildings.”

- SPDG is “one factor that can assist in providing improvements in thermal performance but I consider that other simpler/less intrusive improvements are often overlooked due to the over-publicity that is given to windows.”
- “We take each building on a case by case basis and will allow SPDG where possible.”
- Approving the use of SPDG “would depend on the whole package of change and how it would help preserve the listed building.”
- “Blanket negativity to SPDG and an inability to carefully think ‘where is the demonstrable harm’ caused to the listed building may result in unnecessary appeals.”
- “I do worry that unless a more open-minded approach to energy efficiency in historic buildings is taken then in a world where these issues are considered of great importance there may be a loss of faith in the conservation of historic buildings in principle. Ultimately if the conservation professionals and existing systems cannot be demonstrated to be taking reasonable steps to balance preservation with energy efficiency then such issues might be taken out of our hands in the future.”

There is evidence from local authority databases that these views can lead to contrasting decisions. Table 4 below shows the decisions of conservation professionals from five different local authorities in England to requests to use SPDG in listed buildings. The examples have been chosen because they show commonality of building type, window style and aspect.

Cases 1a and 1b refer to similar types of windows in a rural setting, being replaced with replica windows containing SPDG. The application in one local authority was granted approval whilst the other application, in a different local authority, was not. Similarly, the 18th century, street facing houses in cases 3a and 3b had applications submitted to replace timber windows on their front elevations with replica windows containing SPDG. Again, one was granted approval whilst the other was not.

It is acknowledged that the selected cases are not necessarily directly comparable in every respect, i.e. they may have specific differences that are not directly apparent from the details kept on the databases. Nevertheless, the data illustrates that the relationship between types of alteration, building type and success of SPDG applications is not straightforward and

differences between local authorities exist, mirroring the range of opinions expressed above held by conservation professionals about SPDG.

4. Discussion

The two main findings that emerged from this research are:

1. There appears to be a divergence between Scotland and the rest of the UK in terms of the legislation, guidance and implementation of energy efficiency improvements in historic buildings, particularly in the context of upgrading traditional windows; and
2. There is a wide spectrum of approaches within the conservation community of England towards the use of slim double glazing in historic buildings.

The review of the UK legislative framework and guidance literature on energy efficiency improvements to historic buildings shows that there is a difference in the way that Scotland deals with energy retrofit in its historic buildings compared to the rest of the UK. As discussed by Mazarella [6] such regional differences can also be observed in other EU countries and are the result of the derogation regime that allows countries to decide the levels of exemption applied when renovating historic buildings.

This particular investigation reveals that the guidance issued in Scotland and England/Wales has been diverging, and provides evidence for the belief that a lack of protocol leads to different interpretations in the evaluation of interventions [6]. This is particularly apparent in the attitude towards the retrofitting of SPDG panes into original window frames. In Scotland this is considered to be a worthwhile procedure. Comments from the survey and evidence from the planning database of Edinburgh council suggest that this has resulted in joinery firms becoming skilled in this type of work. In England, the guidance has been sceptical towards the retrofitting of SPDG panes and, as a result, conservation professionals tend not to support it. Again, evidence from the survey and the databases of English local authorities suggest that English joinery firms tend to focus on making replacement windows, rather than retrofitting SPDG.

Both De Santoli [7] and Lopez [8] have called for interdisciplinary cooperation between technical experts in the fields of conservation and energy retrofit. This research shows that

there is some evidence of this happening in Scotland, with Historic Scotland working with Changeworks (an environmental charity focusing on carbon reduction) and universities to carry out research into the impact of SPDG in heritage buildings [9][18]. Another finding from the study was that many conservation professionals were not aware of new developments in slim profile double glazing that makes it more appropriate in a heritage context. This reflects the concern regarding a disconnect between heritage professionals and environmental designers, as highlighted by Cassar [19]. Table 2 in section 3.2.2 above indicates that most conservation professionals have similar concerns regarding SPDG. In light of this, bridging the gap between the shortcomings of SPDG in a heritage context and conservation officers' reservations towards it should not be difficult. The evidence suggests that Scotland's heritage organisations have engaged with research units to investigate the viability of SPDG in an historic context and then worked with product manufacturers to refine the product to make it more suitable to their needs.

It is likely that Scotland's pro-active stance towards energy retrofit, possibly as a result of its more stringent application of energy efficiency standards to historic buildings, has influenced Scottish conservation professionals to seek compromise between conservation of heritage and conservation of energy, thereby reducing the risk of heritage buildings suffering environmental obsolescence. Evidence for this comes from the fact that, where there is a direct conflict between energy efficiency and the preservation of historic material, such as the loss of traditional joinery and historic glass, a far lower percentage of Scottish conservation professionals indicated that they would 'never' consider SPDG compared to a far higher percentage from England. In England, it is apparent that conservation bodies are extremely focused on maintaining historic integrity and many are not prepared to compromise it for the sake of energy efficiency. The approach adopted in Scotland shows similarities to the Italian approach, which, considers "energy efficiency as a tool for protecting, rather than a process of upgrading that conflicts with the conservation requirements", as documented by de Santoli [7].

The results of the three datasets (survey, interviews and local authority databases) demonstrate that there is a wide spectrum of attitudes amongst conservation professionals towards the application of slim double glazing in listed buildings. To demonstrate this, it is possible to separate the views of conservation professionals into three main categories:

1. Firstly, conservation professionals who adopt blanket opposition to SPDG in listed buildings built prior to 1919. They do not allow SPDG in modern replacement windows and are unlikely to allow it in new extensions to listed buildings. Most of them recognise the importance of energy efficiency but do not consider it compatible with retaining historic building authenticity.
2. Secondly, conservation professionals who are prepared to sanction SPDG in listed buildings in limited circumstances, particularly if there is no loss of historic material from the building envelope. Examples would be in modern extensions; to replace an inappropriate modern window; or at the back of a listed building that has undergone alteration.
3. Thirdly, conservation professionals who are broadly supportive of SPDG providing it does not result in unnecessary loss of traditional joinery or historic glass. They recognise the benefits of SPDG in terms of improved thermal performance and comfort levels and would permit it (despite loss of historic building envelope) if it improved the long-term viability of a listed building.

The majority (approximately 50%) of the conservation professionals who took part in this study fall into the second category. Many of the Scottish conservation professionals showed broad support for SPDG and fall into the third category. Conservation professionals from Wales fall into either the second or third categories. Conservation professionals from England show the widest spectrum of approaches and span all three categories. In contrast to Scotland and Wales, all conservation professionals in the first category work for local authorities in England. Cassar [19] wrote of the need for conservation practitioners to adapt current practice to environmental and societal change. This study provides evidence that some of the conservation community engage with this process whilst others may not. Perhaps guidance could be issued that addresses the specific concerns of conservation professionals from the different attitudinal categories identified above, thereby improving the consistency of decisions and reducing confusion amongst historic property owners.

The study also showed that there is regional inconsistency in England itself, in the way that conservation professionals deal with slim profile double glazing in historic buildings. It is likely that the attitude/approach of the local authority where an historic building resides plays an important part in determining whether SPDG can be used, despite the same guidance

applying. This lack of certainty may be a deterrent to historic property owners to undertake energy efficiency improvements and may encourage them to shield behind the exemptions contained in the Building Regulations when carrying out renovations. Thus, opportunities for energy efficiency improvements are missed, which ultimately affects the overall reduction of greenhouse gas emission from existing building stock.

4.1 Further work

Conservation professionals play an important role in determining whether historic buildings become more energy efficient. At the same time as carrying out research into the impact of retrofit measures on the envelope, aesthetics and CO₂ emissions of historic buildings, further research should be conducted on the attitudes and concerns of conservation professionals towards other energy efficiency improvements.

For example, work on retrofit adaptations in historic buildings in Bath has shown that solar PV can make a significant contribution to reducing CO₂ emissions and should be considered alongside, rather than after, the building envelope first approach [20]. This would indicate that similar research into the attitude of heritage bodies and conservation professionals to the incorporation of renewable energy technologies into historic buildings would be extremely beneficial.

Research into the publics' perception of historic buildings where SPDG has been installed (and other retrofit measures), from the perspective of both occupier and onlooker, is needed and would help the conservation community to understand more fully the demand and need for energy efficiency improvements. Such research could also track the long-term performance of SPDG and measure the extent of failures and the reasons behind them. This would enable conservation professionals to offer guidance to homeowners concerning product specifications.

As noted above, the local authority databases on planning applications can potentially be a useful source of data regarding energy retrofit in listed buildings. However, extracting and analysing data is currently a laborious manual process. If ways could be found to extract the data more easily, and in a consistent format that allows automated processing and analysis, then a wider data set could be explored.

In terms of designing research tools, experience from this study indicates that the length of the survey is crucial in terms of ensuring participation and thus size of the data set. It is thus recommended that future research surveys should remain succinct, with questions clearly focused on the research area. As shown in this study, allowing survey participants to add further comments for each question can provide valuable qualitative data regarding their approach, which can be very valuable for interpreting quantitative survey responses.

4.2 Recommendations

Although universal approaches and standardization are not the answer for historic buildings, there is a need for a framework that encourages benchmarking and adaptation and insists on interdisciplinary cooperation. Italy and Switzerland are making headway in this area [8]. In Italy, the AiCARR Guidelines ‘Energy Efficiency in Historic Buildings’ 2014 [21] provide a methodological approach that can be used by all practitioners to objectively decide on the level of energy efficiency to be achieved in historic buildings in accordance with their conservation criteria [7]. A similar approach in the UK which encourages conservation professionals, building engineers and energy specialists to work together on retrofits would greatly improve the comfort levels and carbon footprints of historic buildings without damaging their character or long term health.

Arising from this study, specific recommendations relating to slim profile double glazing can be made:

- Local authorities should publish guidelines on their approach to the use of SPDG in historic buildings thereby improving the consistency of decisions and reducing the number of appeals;
- More research should be undertaken into the retrofitting of double glazed panes of glass into existing frames in order to preserve historic material, improve U-values and reduce condensation;
- More research should be carried out on the long-term performance of SPDG and its failure rates. This will help homeowners to assess the level of quality of different SPDG units and either allay the concerns of conservation professionals or alert them to problems which need to be resolved.

- There should be greater cooperation between product designers, energy technicians and conservation professionals to produce products and systems that meet heritage needs without compromising quality and longevity;
- Product manufacturers should disseminate information on their products to the conservation community; and
- Heritage agencies should recognise the adaptive capacity of historic buildings and see energy efficiency as a means of ensuring their long term survival.

5. Conclusion

This research project reviewed UK legislation and guidance on energy efficiency in historic buildings and investigated the approach of conservation professionals to slim profile double glazing. It has produced results that are consistent with findings from other European studies. In particular, it identifies an inconsistency of approach to energy improvements in historic buildings both at an institutional level and at the point of authorisation/implementation. Regional differences in the levels of exemption granted to historic buildings and disagreement over how/what energy improvements should be made stymies the impetus to cut carbon emissions in a poorly performing sector of the built environment and increases the risk of heritage building stock becoming economically defunct.

Energy efficiency improvements should be considered as a means of protecting and improving historic buildings rather than as a modernisation procedure that conflicts with conservation principles. Designers, energy efficiency technicians and conservation specialists should cooperate to identify appropriate measures that are compatible within the conservation constraints of historic buildings. Conservation professionals should be encouraged by the Heritage Agencies to view energy efficiency improvements as progress towards a goal of adapting historic buildings to an emerging low carbon paradigm.

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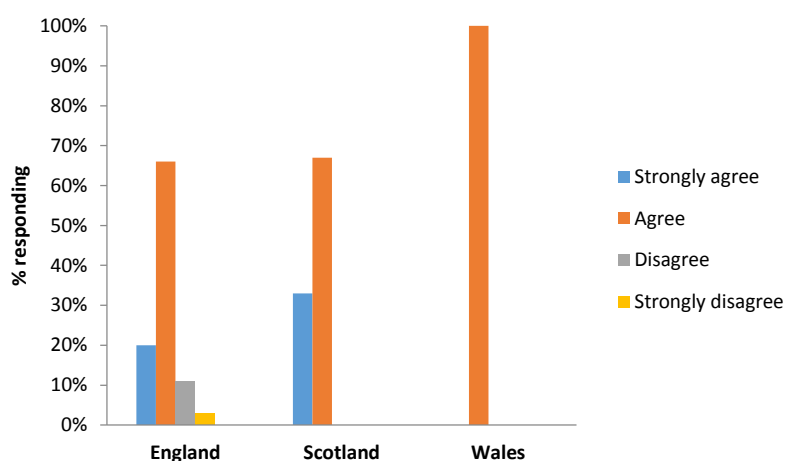


Figure 1: Responses according to region as to whether energy efficiency in listed buildings is important.

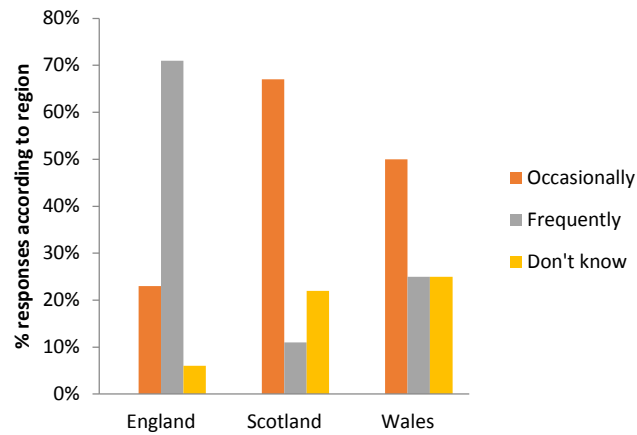


Figure 2: Responses according to region as to whether single glazing is stipulated when replacing a traditional window.

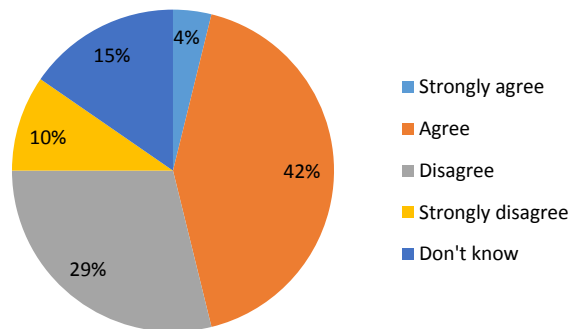


Figure 3: Total responses to whether SPDG is an important factor in improving the thermal performance of listed buildings.

	Original single glazing	Standard double glazing (gas filled cavity)	SPDG – slim profile double glazing (gas filled cavity)	Secondary double glazing (extra pane fitted behind original single glazing)
Profile sketch (not to scale)	<InlinelImage1>	<InlinelImage2>	<InlinelImage3>	<InlinelImage4>
Total depth (glazing & cavity)	4-6 mm [9]	20-25 mm [9]	8.2-16 mm [9]	60-100 mm [15]
Typical U-value	5.75 W/m ² K [10]	1.21-2.76 W/m ² K [10]	1-2.8 W/m ² K [9]	1.6-2.1 W/m ² K [10]

Table 1: Comparison of original (single) glazing and typical replacement options (sketches are for illustration only, not to scale)

	Thickness of glazing bars	Glass reflection	Colour/look of spacers	Visibility of edge seals	Lifespan	Bedding material	Other
Mean	1.89	3.09	3.30	4.26	4.47	4.81	6.55
Highest rank	1	1	1	1	1	1	1
Lowest rank	5	8	8	8	8	8	8
Standard deviation	1.20	1.93	1.43	1.33	1.85	1.51	1.7
Total responses	47	47	47	47	47	47	47

Table 2: Statistical analysis ranking different concerns regarding SPDG in historic buildings, with 1 indicating the highest and 8 the lowest ranking concern.

	City of Edinburgh		Bath and North East Somerset	
	Single Glazing	SPDG	Single Glazing	SPDG
Applications	7	57	12	9
Applications granted	6	52	12	7
Applications refused	0	2	0	2
Applications withdrawn	1	3	0	0

Table 3: Listed building consent applications relating to SPDG in windows received by the councils of Edinburgh and Bath and North East Somerset from 1 October 2014 to 1 April 2015 [16][17]

Location no.	Local authority	Date	Building type	Details of application	Decision
1a	Vale of White Horse	12/2013	18 th century thatched cottage	Replace all timber casement windows with replica windows containing SPDG.	Allowed
1b	Bath & North East Somerset	03/2015	17 th century farmhouse with later additions	Replace timber casements with replica windows containing SPDG.	Refused
2a	Rushcliffe	11/2014	17 th century farmhouse with later additions	Replace all timber sash windows on front elevation with replica windows containing SPDG.	Allowed
2b	Basingstoke & Deane	10/2013	19 th century estate cottage	Replace timber casements on front elevation with replica windows containing SPDG.	Refused
3a	Vale of White Horse	09/2014	Mid 18 th century house facing the street	Replace timber windows on front elevation with new windows of different pane configuration plus SPDG.	Allowed
3b	Cotswolds	04/2013	Late 18 th century terraced house facing the street	Replace two timber sash windows on front elevation with replica sashes containing SPDG.	Refused

Table 4: Examples of applications to use SPDG in listed buildings from different local authorities in England.